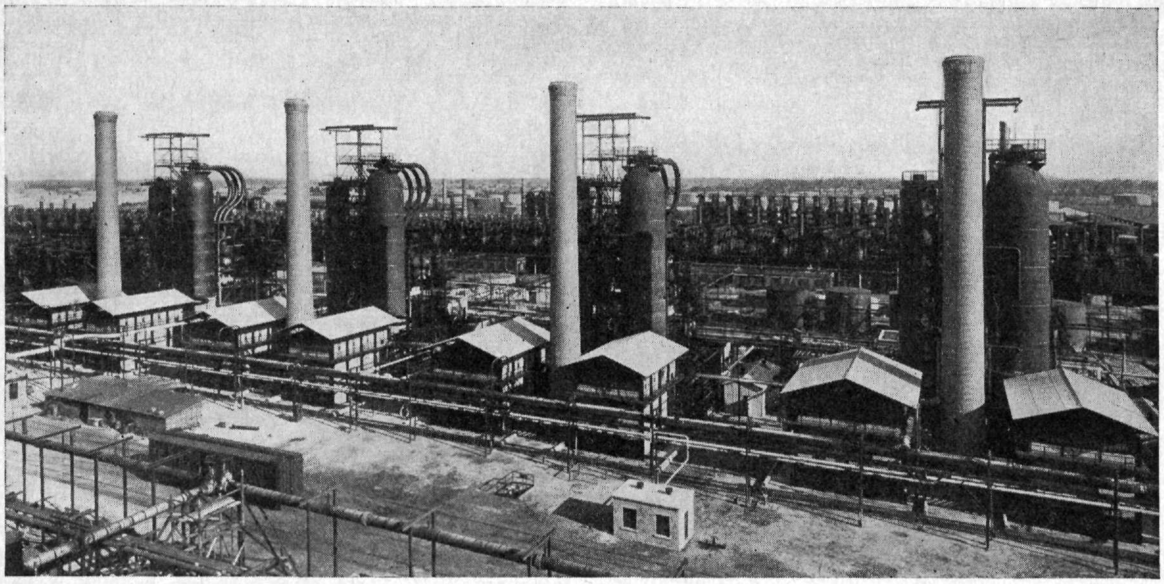


—*Courtesy Foster Wheeler.*

Largest Single Battery of Tube Stills in the World

CRACKING THE WHIP TO MAKE GASOLINE

By MORGAN JONES

ENGINEERS produce gasoline by making oil molecules join hands and play "crack the whip." In the past ten or fifteen years, "cracked" gasoline has become one of the most important commodities in our national economic system. Since the development of vehicles powered by internal-combustion motors had brought about a tremendous demand for fuel, the natural resources of the world were hard put to satisfy this demand. Increasing the yield by making gasoline artificially from heavy oils proved to be a satisfactory solution to this pressing problem.

Gasoline is distilled from petroleum, or crude oil. Petroleum is the result of the decomposition of animal and vegetable material under pressure. It is generally considered a step in the formation of coal. It is remarkably simple in composition, being made up of two elements: hydrogen and carbon.

The molecules of petroleum vary greatly in size and weight. The process of refining consists of separating these molecules according to weight into certain prearranged group of "fractions." Some of the more important fractions in the order of their increasing molecular weights are crude naphtha (gasoline and naphtha), lamp oil, lubricating distillate (paraffin wax, gas oil, neutral oil, etc.), and cylinder stock (cylinder oils and asphalt).

Now, gasoline represents but a small per cent of the total quantity of petroleum undergoing distillation. In order to produce a small quantity of gasoline, the refiners had to produce along with it an amount of comparatively valueless by-products. At one time it was feared that this situation would bring about the collapse of the oil industry. However, the practice of breaking down these heavy by-products into perfectly good, if not superior, gasoline by chemical methods, has averted any economic catastrophe that might have come about.

Actually, cracking may not be considered a new process. As early as 1825, a man by the name of Henry, heated animals oils and noticed that a fixed gas was obtained. In 1855, Benjamin Silliman, a professor of chemistry at Yale, conducted some important experiments along this line on Pennsylvania petroleum. The first patent for a process was taken out in 1860 by Atwood, who discovered a method for increasing the yield of kerosene. The birth of the present industry came with the patents obtained by Dr. W. M. Burton in 1917.

CHEMISTRY OF THE CRACKING PROCESS

In order to understand the changes that take place in the makeup of petroleum when it is cracked, one must first have some knowledge of the molecular construction of petroleum. Suppose an oil molecule is made up of a number of carbon atoms arranged in line and helu to-

(Please turn to following page)

gether by static electrical bonds. Each carbon atom would have several hydrogen atoms sticking to it. Now if it were possible to snap this string of carbon atoms like a whip, some of those on the end might fly off. High temperature and pressure is the force that cracks the whip.

It is interesting to note that this rearrangement takes place at a characteristic temperature which may be between 650 and 700 degrees F. This is true for all oils. Praffin hydro-carbons are much more stable toward cracking than are olefins and naphthalenes. The lighter an oil is, the harder it is to crack it. Thus, much better results are obtained when tar or asphalt are used than in the case of kerosene or lubricating distillate.

Phases of Cracking

The various processes of cracking may be divided roughly into two general types: the liquid phase, and the vapor phase. In the liquid phase process, the oil is placed in a still, heated to a temperature of from 650 to 700 degrees F., and the resulting vapors condensed under a pressure of from 4 to 6 atmospheres.

The vapor phase differs from the liquid phase chiefly in that the oil is volatilized before it is passed into the cracking still. Generally the vaporized oil is cracked under pressure and then condensed at atmospheric pressure. The Rittman process uses kerosene distillate or fuel-oil distillate.

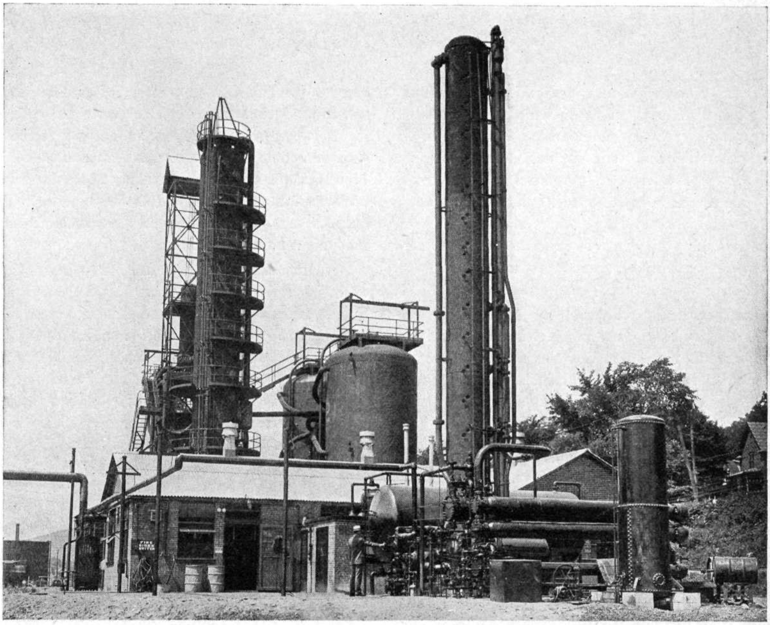
Patented Cracking Processes

Most of the cracked gasoline used today is cracked by the Burton process, invented and patented by Dr. W. M. Burton in 1917, or by some one of its modifications. The apparatus used in this process consists of heavy horizontal steel cylinders, thoroughly insulated with asbestos, from the top of which is a long run-back, exposed to the air, for the purpose of returning to the still any undecomposed oil. Distillation is carried on at a temperature of about 750 degree F., and a pressure of 85 pounds per square inch.

The Burton process has been modified by various patentees. The most important modifications are the batteries of stills set up by Clark, and the impact process. Clark, by connecting a number of the stills in series to form "batteries," has succeeded in materially increasing the yield of gasoline without greatly increasing the cost of operation. The stills can be run from 48 to 60 hours before the carbon must be cleaned out. The following table shows typical results of this type of still:

Gravity of charge	28°B.
Gravity of feed	20°B.
Cracked distillate	60%
Residuum	37%
Loss	3%

The loss represents the carbon deposited in the still and



—Courtesy Foster Wheeler.

Pressure Distillate Stabilizing Unit—Cracking Plant in Background

the fixed gases formed (methane).

The cracked distillate yields 52% gasoline or 31.1% of the through put. Some processes use forced circulation of the oil through the cracking tubes to decrease carbon deposition.

In the impact process, heated oil is atomized through two diametrically opposed jets which impinge upon each other. The advantage of this set-up is that ionization takes place in the molecule, thus increasing the yield.

Difference in the gasoline yield is due chiefly to difference in time. All processes give approximately the same results if time is considered. "Recycling"—running the residuum through the still a second time—increases the yield, but, of course, it also increases the time consumed.

The Rittman process is like all others in that it uses the principles of high temperatures and pressures, but it differs by using the oil in the gaseous state. The oil is first vaporized, then passed downward through heated tubes where it undergoes decomposition. Condensation takes place under atmospheric pressure. Kerosene distillate or fuel oil distillate are generally used as the charge. Its safety features are the greatest advantages of this process. By first vaporizing the oil, the sudden expansion of vaporization is avoided in the cracking tubes, thus decreasing the explosion and fire hazard.

The formation of free carbon which clogs the cracking tubes has always been a great problem in cracking oil. One of the most successful attempts at solving this problem is the Bowie-Gavin process. Since some inert material, such as sand or crushed shale is mixed with the oil, the process necessarily must be vapor phase. The inert material is used to entrain the carbon and prevent its adhering to the walls of the still.

The still is conical in shape, with a small opening between the sides of the cone and the base. This space is filled with sand to effect a seal. The oil, mixed with the proper amount of sand, is pumped into the still. As the oil is heated, and cracking begins, the cracked distillate and fixed gases pass out through the top, while the carbon occludes to the sand and settles to the bottom. Revolving scrapers push the spent solid to the outside through the opening, always preserving the seal. More oil is continually added to replace that cracked. Heavy tars and semi-solid asphalts are used. The loss of from 12% to 14% represents the methane and carbon formed. The former, however, is valuable for fuel. The process operates most efficiently at a temperature of about 752 degrees F.

There have been a great many attempts to accelerate the cracking reaction by the use of catalyzers. Aluminum chloride is the most efficient discovered so far. The process using aluminum chloride as a catalyzer is known as the McAfee process. Its advantages are that it operates at a lower temperature (550 degrees F.) and that the residuum remains suitable for lubricating purposes. Its disadvantages are the high cost of the catalyzer and the difficulty of reclaiming it after it has been used once.

Very recently there has been developed a process of producing gasoline by adding hydrogen to the oil. This reaction takes place only at very high temperatures and in the presence of catalysts. Its greatest advantage is the large yield of gasoline. As much as 80% has been recovered by using this method. Time will show whether or not this process is commercially practical.

Hall has devised a method of solving the carbon problem by sudden expansion. Like the Rittman process, it is vapor phase. The vaporized oil is passed into cracking tubes which are one inch in diameter and three hundred feet long, through which it travels at the rate of seventy gallons per hour. A pressure of from 50 to 70 pounds per square inch, and a temperature of 550 degrees C. is maintained in the tubes. After going through the cracking tubes, the gases pass into a vertical pipe, one foot in diameter, and, in doing so, strike against a baffle. The kinetic energy of the swiftly moving gases is changed into heat, which raises the temperature materially without the application of external heat, and, at the same time, the carbon is deposited.

Characteristics of Cracked Gasoline

A number of its characteristics differentiate cracked gasoline from the ordinary variety. It has a yellow or amber color, and a varnish-like odor, which are due to resinous colloids present. It is almost impossible to remove these impurities, and, since they would foul the motor, the gasoline cannot be used in the pure state. However, a very satisfactory fuel is obtained by blending it with straight-run or casinghead gasoline. The superiority of the cracked gasoline is due to the fact that it decreases detonation and increases mileage.

When the high-compression heads were first used, a very disagreeable knock resulted. This was due to the fact that gasoline burns so fast that the movement of the piston cannot accommodate the expansion of the gases. The resulting high pressure wave gives a metallic knocking sound when it strikes the walls of the combustion chamber. This also results in lost power. Since cracked gasoline is slower burning, it does away with the knock and supplies power throughout the course of the piston stroke, thus increasing the mileage.

Economic Aspects of Cracking

The almost universal use of high-compression motors has created a great demand for gasoline of this type. The cheap production of this gasoline has done much to facilitate the development of these motors.

In addition to the good it has done the automotive industry, the cracking of gasoline has brought about marked improvements in the petroleum industry. Fifteen years ago, the world was confronted with a great underproduction of gasoline, while, at the same time, a great many other petroleum products were being discarded. Largely through the results of the cracking of gasoline, there is now an overproduction, while the distillates and residua, that were formerly discarded, are now being used in the manufacture of the gasoline. This has been a great stride in the conservation of petroleum.